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(12) (19) (CA) **Demande-Application**

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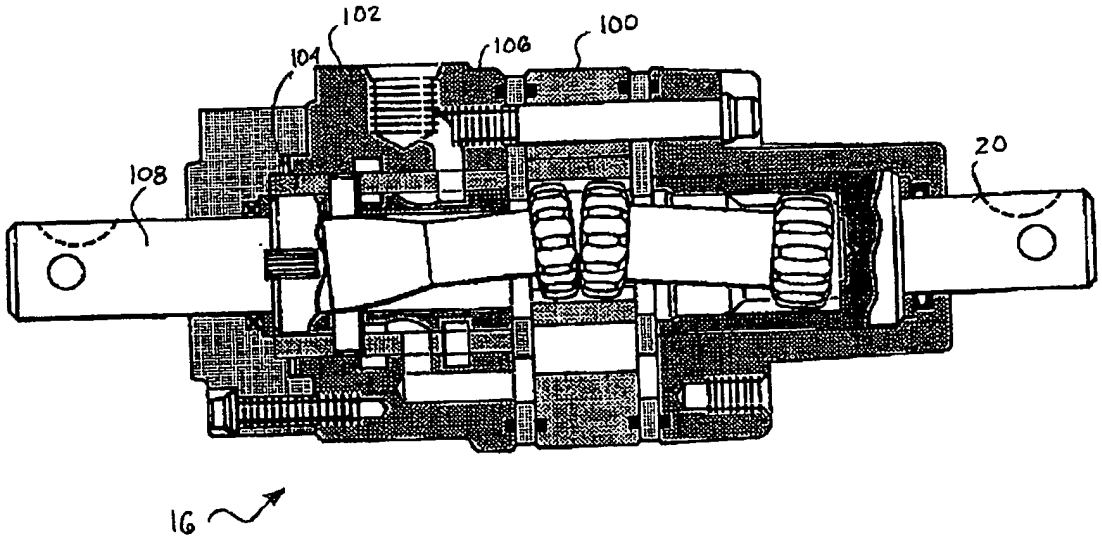
(54) **MECANISME D'ENTRAINEMENT A TAUX VARIABLE POUR CHARIOT AERIEN**

(54) **AIRCART VARIABLE RATE DRIVE**

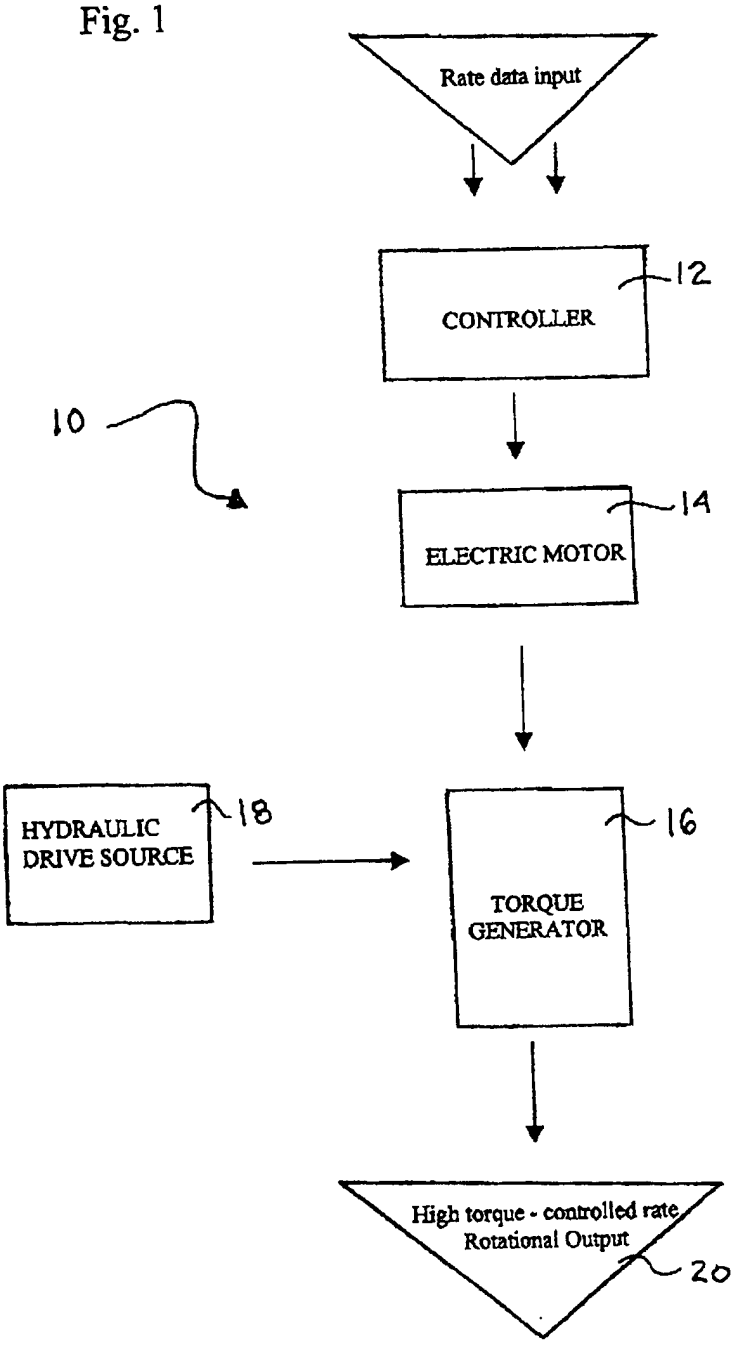


(57) The invention relates to a hydraulically operated variable rate rotational drive. A rotational drive rate is provided to a hydraulic motor by rotational input from an electric motor at a controlled rate. The electric motor rotates a rotary valve which opens the hydraulic connection to the hydraulic power source. Hydraulic fluid rotates the motor closing the hydraulic connection until the next rotation from the electric motor. This drive incorporates a torque generator, commonly available as used for incremental rotational drive such as power steering. Continuous hydraulic rotational drive from the motor accordingly matches the continuous input rate from the electric motor. The drive is particularly suited for controlling metering rates of rotational meters without the need for gearing. The rate is advantageously variable while in operation, saving significant time in metered seeding or fertilizing operations.

Abstract of the Disclosure

The invention relates to a hydraulically operated variable rate rotational drive. A rotational drive rate is provided to a hydraulic motor by rotational input from an electric motor at a controlled rate. The electric motor rotates a rotary valve which opens the hydraulic connection to the hydraulic power source. Hydraulic fluid rotates the motor closing the hydraulic connection until the next rotation from the electric motor. This drive incorporates a torque generator, commonly available as used for incremental rotational drive such as power steering. Continuous hydraulic rotational drive from the motor accordingly matches the continuous input rate from the electric motor. The drive is particularly suited for controlling metering rates of rotational meters without the need for gearing. The rate is advantageously variable while in operation, saving significant time in metered seeding or fertilizing operations.

Fig. 1


Rate data input
CONTROLLER
12
10
ELECTRIC MOTOR
14
HYDRAULIC DRIVE SOURCE
18
TORQUE GENERATOR
16
High torque - controlled rate Rotational Output
20

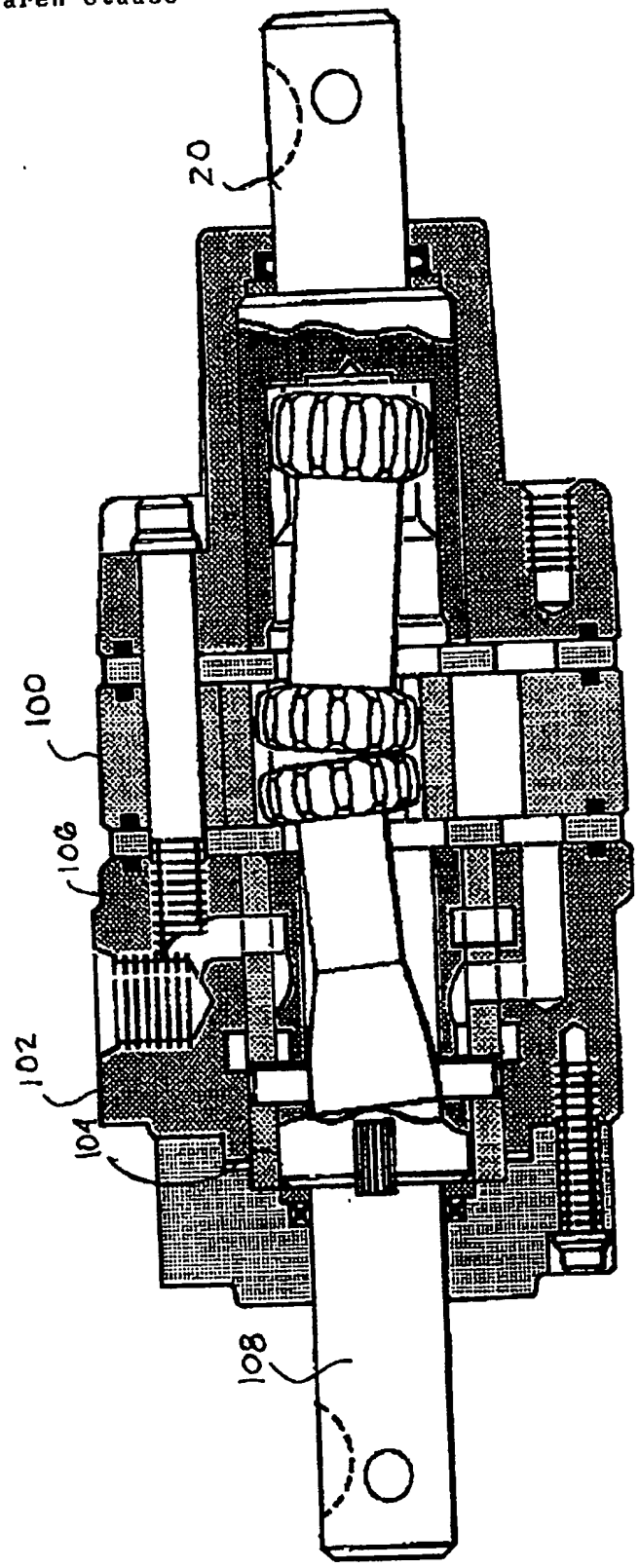


Fig. 1A

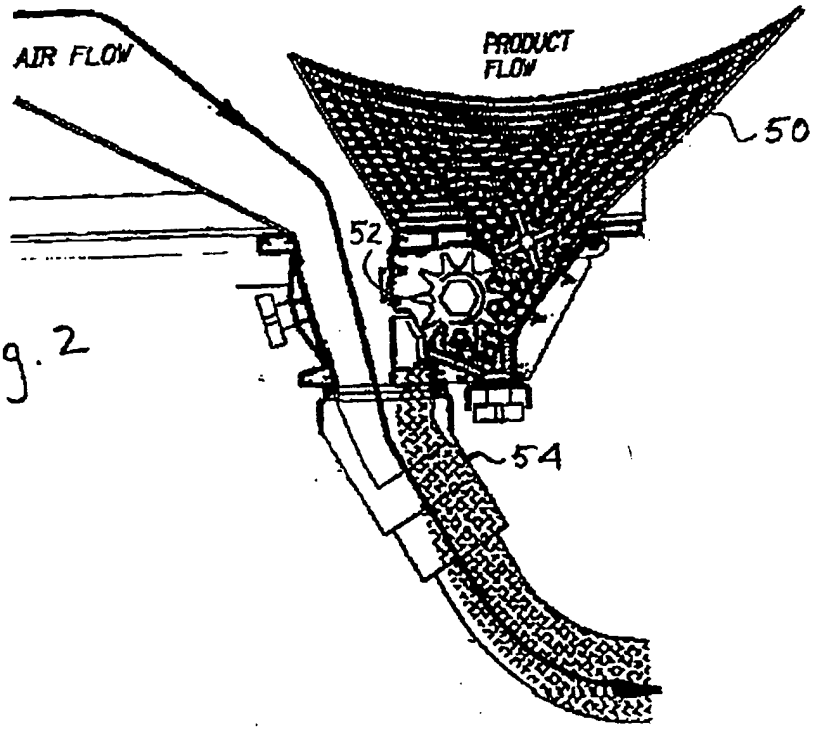
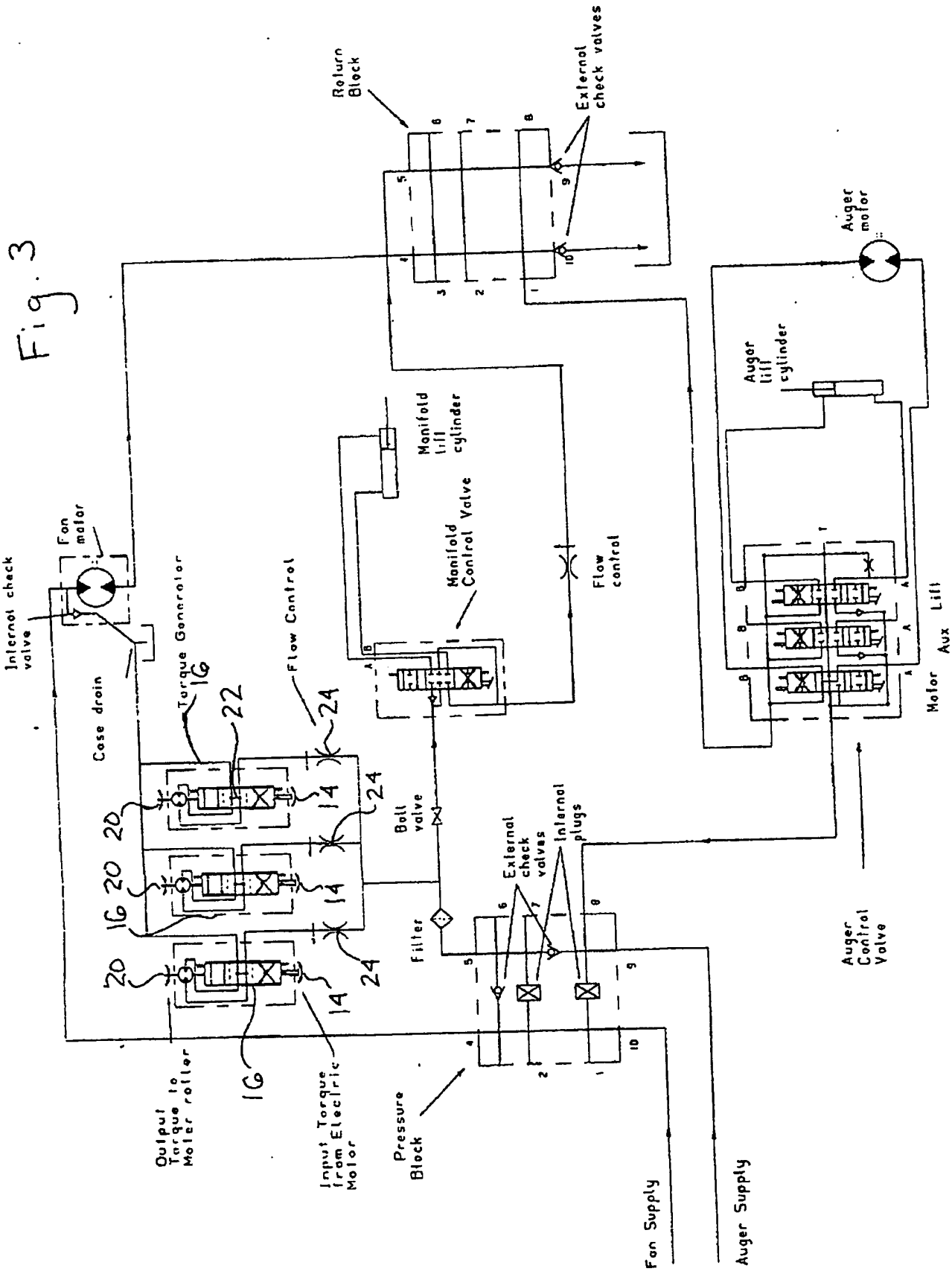


Fig. 2

Fig. 3


Return Block
External check valves
Auger motor
Auger lift cylinder
Manifold lift cylinder
Manifold Control Valve
Flow control
Fan motor
Internal check valve
Torque Generator
Flow Control
Case drain
Motor Aux Lift
Ball valve
External check valves
Internal plugs
Filter
Auger Control Valve
Output Torque to Motor roller
Input Torque from Electric Motor
Pressure Block
Fan Supply
Auger Supply
16
22
24
14
20

VARIABLE RATE HYDRAULIC DRIVE CONTROL

Field of the Invention

This invention relates to a hydraulically operated variable rate rotational drive, particularly for use with agricultural implements such as feed and fertilizer meters.

Background of the Invention

A controlled rate rotational drive is needed in a variety of agricultural implements, particularly for metering materials such as fertilizer and seed. An air cart, for example, used to meter and deliver seed, fertilizer and other materials requires adjustable metering control. For consistent application of these materials, delivery rates must be referenced to the ground speed of the air cart. In the past this has been done by mechanically linking axle rotation of a ground engaging wheel to the metering device. A change to the metering rate is made by manually altering the gear ratio when the device is stationary. Typically an average fertilizer application is determined and the metering rate is set once per field. However, this mechanical drive is not always an accurate indication of ground speed. Cornering, for instance, forces the ground engaging wheels to travel at different rates.

The practice of averaging fertilizer requirements for a complete field often results in over-fertilizing of some areas and under-fertilizing others. For example, high spots, where fertilizer often leaches out with the ground water, may be under-fertilized and the low spots adjoining them, that receive the fertilizer from the high spots may be over-fertilized. A more efficient method of applying fertilizer is needed to permit variation of the amount applied over the field to make adjustments according to terrain, to adjust application of herbicide to known problem areas, or to make other adjustments according to the soil requirements or in response to past yields. With current equipment, the time required to adjust the metering rate manually makes this practice prohibitively expensive.

Fertilizer rates are beginning to be evaluated from satellite or GPS field maps as disclosed in Canadian Patent No. 2,095,462 issued in 1993 to Ag-Chem Equipment Co.

Inc. This device requires a digital field map of soil types or other collected data and a fertilizer map storing desired distribution rates, a position locator to determine implement field position relative to the maps, a speed indicator and a processor for determining and controlling the rate of dispensing of each fertilizer type. The patent, however, does not disclose how the fertilizer rate is to be varied. The numerous changes implied are clearly not practical manually.

A means for variable adjustment to the metering rate while in operation is needed. Some designs have been proposed to provide this function. For example as disclosed in United States Patent No. 3,490,654 issued to Fischer in 1970, a manifold providing adjustment to the flow and pressure of the air source is used to vary the distribution rate. This is a costly arrangement, and the change in air flow is not always compatible with a controlled distribution rate. Nor is the distribution accurately controlled without metering the materials.

A Concord Inc. design for variable response to position and application data uses a flow control valve such as a pressure compensated control valve responsive to a linear actuator to regulate flow to a hydraulic motor which operates the meter. Speed control by automatically adjusting the flow control is not precise, particularly for accurate metering control. Hydraulic drive is subject to load changes depending on other system requirements affecting system pressure and flow rate. The flow control compensation is not sufficient to accurately control the output. Variation in output resistance due to load on the meter also causes fluctuation in the drive, and consequently metering rate.

Hydraulic motors, most conveniently available as an agricultural implement power source, have proved difficult to control precisely enough for metering purposes. It is desired to provide a hydraulic rotational drive adapted for variable adjustment in operation suitable for operating a rotational metering device.

Summary of the Invention

Hydraulic drive is commonly available from the tractor for agricultural implements and provides an available power source for a metering drive. It must, however, be responsive to a controller providing electrical input to control the output rate of rotational drive. Electrical input is advantageously made through a DC electric motor with a reduction gear box. The controller provides a signal to the electric motor to vary the speed of the electric motor in response to manually selected settings or automatically based on preprogrammed and operational data. The electric motor provides rotational input into a hydraulic torque generator which converts the hydraulic drive into a high torque rotational output which can be coupled to a meter. The rate of rotational input from the electric motor determines an equal rate of output drive.

Accordingly, the present invention comprises an apparatus for use with a hydraulic power source, for variable rate rotational drive comprising:

a hydraulic motor providing a rotational output drive, including a rotary valve for operatively linking the hydraulic motor to the hydraulic power source;

rotational input means for operating the rotary valve;

controller means for selectively controlling the rate of the rotational input means, wherein the rotational output rate is proportional to the rotational input rate.

In an alternative preferred embodiment the present invention comprises a controlled variable rate drive for use with a hydraulic drive system for operating a rotational meter comprising:

controller means for providing rotational rate signals;

electric motor for receiving rotational rate signals and providing rotational input drive corresponding to the rate signal received;

torque generator having a rotary valve at an input for coupling to the rotational input drive of the electric motor, and a hydraulic motor for producing a rotational drive proportional to the rate of the rotational input for driving the meter.

In a further preferred embodiment the present invention comprises a meter for granular material having a variable rate drive comprising:

a rotational meter wheel for measuring a volume of material in regular intervals;

a hydraulic motor coupled to the meter wheel for providing rotational drive;

a rotary valve means for providing an operative connection from a hydraulic power source to the hydraulic motor;

electric drive means for rotating the rotary valve means;

controller means for controlling the rate of drive from the electric drive means to the rotary valve whereby the rate of the rotational drive from the hydraulic motor is proportional to the rate of drive from the electric drive means.

It is an advantage of the present invention to provide an accurately controllable hydraulic rotational drive. Advantageously, the present invention provides a widely variable rate control without discreet gearing limitations.

It is a further advantage of the present invention to provide variable adjustment during operation.

Further advantages will be apparent to persons of skill in the art from the following detailed description, by way of example only, with reference to the following drawings in which:

Brief Description of Figures

Figure 1 is a block diagram illustrating the primary elements of the present invention;

Figure 1A is a sectional view of a commercially available torque generator;

Figure 2 is a scrap drawing of the metering assembly of a seed and fertilizer delivery air cart;

Figure 3 is a diagram of a hydraulic circuit incorporating the invention arranged in parallel in the hydraulic drive line of an air cart.

Like numerals are used throughout to designate like elements.

Detailed Description of Preferred Embodiments

The invention, shown generally at 10 in Figure 1 includes a controller 12 for processing preprogrammed data with sensor input data such as ground speed or meter speed. The controller 12 generates an input signal to an electric motor 14. The speed of rotation of the motor 14 is controlled to input a low torque rotational drive rate into a torque generator hydraulic motor 16. The torque generator 16 is coupled to an hydraulic drive source 18, for instance from the tractor. The electric rotational input directly controls an output rate 20 of high torque hydraulically powered rotation. The motor 14 may be provided with a speed changing transmission which would change the proportion between the motor and the torque generator 16. The input into the torque generator 16 and the output 20, however, remain equal.

Torque generators are primarily provided for use in power steering, and other applications, where a limited number of rotations are permitted for input. In the present application the rotations are not limited, and may be substantially continuous in either direction. The torque generator is suited to this application because it provides an output directly responsive to the input rate, offering a precise rate control mechanism to a hydraulic motor.

The speed of the electric motor 14 is conveniently controlled by pulse width modulation. Rotation of the motor 14 operates a rotary hydraulic valve in the torque generator 16. The torque generator, such as the Eaton series #217 and #227, seen in Figure 1A, consists of a hydraulic motor 100 and a rotary hydraulic valve 102. The valve 102 includes two cylindrical components, housing 106 fitting over the sleeve 104 co-axially with close tolerance between mating surfaces. The cylinders 104, 106 each have an arrangement of fluid ports. One valve cylinder 106 is attached to the rotational output 20 and sleeve 104 is attached to the rotational input 108 from the electric motor 14. As the input cylinder 104 is rotated, ports are aligned to direct hydraulic power to the motor 100 of the torque generator 16. The motor 100 operates to rotate the output 20 in response to the flow, and this causes the second valve cylinder 106 linked to it to move, changing the alignment of the ports to restrict flow. Movement between cylinders 104, 106 is limited by a link

between them permitting a small relative movement for amplification. This ties the output 20 to a direct 1:1 relationship to the input rate. Further movement of the input 108 affects following movement of the output 20 in a direct relationship. The valve 102 of the torque generator allows operation in either direction or allows bypass of the fluid power when there is no rotation. The torque generator 16 thus acts as a torque amplifier for providing a rotational power output 20 proportional to a low power, low torque controlled rotational input. The electric motor 14 might rotate the motor 100 if the hydraulic power fell below a required pressure, since there is a direct linkage. The small 12V motor could not stand such a load, consequently a pressure sensor for the hydraulic pressure is provided to prevent this.

A number of agricultural implements may incorporate a controlled variable rate hydraulic drive. Seed and fertilizer metering is one operation where a system for "on-the-go" or in operation rate adjustment has been actively sought. In a seeding implement such as an air cart, the controller 12 varies the speed of the electric motor 14 in response to data from a ground speed sensor, such as a Hall effect sensor which detects rotation of a toothed wheel, commonly used in the art, together with operator settings such as product delivery rates (lbs./acre), width of the seeding implement and calibration data. The controller 12 may also vary the speed of the electric motor 14 in response to manual setting changes to alter the application rate; or to a processor processing collected data in combination with a satellite positioning system, such as GPS. The electric motor 14 is conveniently a 12 Volt DC motor with a reduction gear box. Only a small power source is needed to open and close the valve of the torque generator 16 providing the impulse to control the drive rate. The speed of the motor 14 is controllable by pulse width modulation.

A seed cart metering device is shown in Figure 2. A portion of a product tank 50 is shown, from which seed, fertilizer or other product drops by gravity onto a metering wheel 52. The wheel 52 is fluted to measure a specific amount in regular increments. Each measured quantity of product is introduced into a manifold 54 with a high velocity air stream. A continuous rate of product is delivered in the air stream to the seeding or fertilizing implement to be distributed through a plurality of distributor tubes across a

width of soil. To apply a constant application rate of product, metering must be responsive to the ground speed of the implement. Additional control may be desired to vary the application rate according to demands of the terrain or other factors. Direct drive from the output of the torque generator 16 provides controlled hydraulic drive to the meter responsive to an electronic controller.

An air cart may have a number of separate tanks 50 for delivering different products simultaneously, or the multiple tanks may be used sequentially to deliver one product. Each tank 50 has a separately controllable meter which, depending on the products applied, may operate at different rates. The central controller 12 provides rate control data to each meter. Each meter must be calibrated to the product delivered before operation, since the size, granularity, moisture content and other factors will affect the metering rate for the same metering wheel 52.

The drive from the hydraulic power source 18 for the meters may be arranged in series, or preferably in parallel as illustrated in the hydraulic diagram shown in Figure 3. Most torque generators available, originally designed for power steering applications, do not accommodate back pressure and consequently include a fluid bypass 22. For use in an agricultural hydraulic drive system, this bypass is not necessary. The additional hydraulic circuitry reduces the available hydraulic power for other systems. A pressure compensated flow control valve 24 is preferably incorporated in each meter drive line to minimize the total flow through the torque generator 16 to conserve fluid power for other systems. A flow control valve such as the FXCA-XAN manufactured by SUN is appropriate for the purpose. This valve 24 can limit flow to 1 gallon per minute to each torque generator so that the amount of fluid bypassed during no rotation in minimized. A pressure reducing control valve may be used to control output pressure to prevent possible damage to the metering mechanism.

In operation in an air cart, as illustrated in the diagram of Figure 3, the tanks 50 are loaded with one or more products. Calibration tests are run for each product and the controller is programmed with delivery rates and width of application. A tractor draws

the air cart and seeding implement on a seeding path in the field. A sensor provides the controller with ground speed information which the controller processes to vary the metering rate as necessary. With interface to an additional processor, field data may be preprogrammed to be responsive to satellite positioning systems for signaling the controller to change the application rates in operation. Alternatively, manual adjustments for known field conditions can be made to the application rates on-the-go.

Hydraulic power 18 from the tractor provides drive to the hydraulic motor of each of the three torque generators 16 in parallel. Rotational input from the electric motors 14 at a rate signaled from the controller opens a rotary valve in each of the torque generators 16. This allows hydraulic fluid under pressure to rotate the hydraulic motor until the rotary valve is closed again. In this manner the hydraulic rotational output 20 follows the electrical rotational input directly. The rotational output 20 is coupled to the metering wheel 52 providing a controlled drive rate.

The metering control is also advantageously adaptable to control metering devices for row crop precision planting devices or "singulators" in addition to many other controlled rotation implements.

Numerous alternative embodiments will be apparent to persons of skill in the art without departing from the spirit and scope of the invention as defined in the claims attached.

Claims

What is claimed is:

1. An apparatus for use with a hydraulic power source, for variable rate rotational drive comprising:

a hydraulic motor providing a rotational output drive, including a rotary valve for operatively linking the hydraulic motor to the hydraulic power source;

rotational input means for operating the rotary valve;

controller means for selectively controlling the rate of the rotational input means, wherein the rotational output rate is proportional to the rotational input rate.

2. An apparatus as defined in claim 1, wherein the rotational input means comprises an electric motor.

3. An apparatus as defined in claim 2, wherein the input rotation and the output rotation are not limited by number of rotations.

4. An apparatus as defined in claim 3, wherein the electric motor is responsive to pulse width modulation for rate control from the controller means.

5. An apparatus as defined in claim 3, wherein the hydraulic motor comprises a torque generator providing an output rate equal to the input rate.

6. An apparatus as defined in claim 5, wherein the rotational output is coupled to a rotational meter.

7. An apparatus as defined in claim 6, wherein the controller means processes ground speed data, and application rate data to generate a rate for the input means for controlling a selected meter rate.

8. An apparatus as defined in claim 7, wherein the controller means generates a plurality of rates to a plurality of electric motors associated with a plurality of torque generators and rotational meters.

9. An apparatus as defined in claim 8, including a flow control valve associated with each torque generator for limiting the total hydraulic flow through the torque generator.

10. A controlled variable rate drive for use with a hydraulic drive system for operating a rotational meter comprising:

controller means for providing rotational rate signals;

electric motor for receiving rotational rate signals and providing rotational input drive corresponding to the rate signal received;

torque generator having a rotary valve at an input for coupling to the rotational input drive of the electric motor, and a hydraulic motor for producing a rotational drive proportional to the rate of the rotational input for driving the meter.

11. A controlled variable rate drive as defined in claim 10, further including sensor means for providing data to the controller means for generating a rotational rate.

12. A controlled variable rate drive as defined in claim 11, wherein the sensor means comprises a ground speed sensor for continuously providing ground speed data to the controller means.

13. A controlled variable rate drive as defined in claim 13, wherein the electric motor is responsive to pulse width modulation for rate control from the controller means.

14. A controlled variable rate drive as defined in claim 10, including a pressure reducing control valve to control hydraulic input to the hydraulic motor from the hydraulic drive system.

15. A meter for granular material having a variable rate drive comprising:

a rotational meter wheel for measuring a volume of material in regular intervals;

a hydraulic motor coupled to the meter wheel for providing rotational drive;

a rotary valve means for providing an operative connection from a hydraulic power source to the hydraulic motor;

electric drive means for rotating the rotary valve means;

controller means for controlling the rate of drive from the electric drive means to the rotary valve whereby the rate of the rotational drive from the hydraulic motor is proportional to the rate of drive from the electric drive means.

16. A meter as defined in claim 14 further including a flow control valve for limiting the flow from the hydraulic power source through the hydraulic motor.